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Management of Technological Change and Quality in Ship Production

IVA-2

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ABSTRACT

Ship production, as other manufacturing and assembly activities, must keep up with technology to assure achievement of required productivity, quality, and technological advance expected by an increasingly demanding market place. The ship market has not only become technologically sophisticated, but customers now no longer buy on price alone. They want quality in design, detailing, operability, maintainability, reliability, usability, all in addition to a fair price, reliable delivery schedule and effective follow on service. In other words, the shipbuilding industry is finally emerging as a market conscious, responsive industry aware of user needs.

To perform this newly rediscovered function, shipbuilding has to assure better management of technological change in both product and process technology and assure continuous total quality management from design and production to delivery and follow. Many shipbuilders are new at this because many assumed a seller's market place.

In this paper, the management of technological change and quality in ship production is presented as a formal step by step procedure which should be undertaken at regular (quarterly or at least yearly) intervals to assure that the yard maintains its quality and performance in process and product terms.

INTRODUCTION

The rapid technological change both shipbuilding products (ship technology) and ship production technology, as well as the increasing pressure of changes in the availability and costs of factors or resources used requires a more effective, timely and responsive management of ship production technology. As noted in other industries, changes in product and process technology are invariably tied to demands not only for improved product quality, but total quality management. In this paper, we review the major aspects of effective management of technological change and total quality.

Technological change which for a long time was more an issue of prestige and capacity than a management decision based on the need for performance in financial, quality, and product effectiveness terms, is finally emerging as the single, most important function of shipyard management.

Similarly, quality - which for too long implied meeting (often minimum acceptable) standards - now means achievement of near perfection in product design, process and assembly performance, schedule, and product delivery and backup. In other words, quality now means meeting customer requirements and expectations.

Zero defect or achievement of the highest quality possible in processes does not by itself constitute quality performance. It includes the effectiveness or fitness for use of the product (the ship), it includes quality of management from design to post delivery customer support, and it includes a never ending thriving towards greater perfection. It also involves quality in organization, team work, and interpersonal relations. As a result, quality performance improves the motivation and commitment of all in the organization to improvements in performance. In other words, effective technological change (in product, management, procedures, and processes), and total quality are interdependent.

Over the years the link between technological change and quality has been forged by people like:

- Deming in Statistical Process Performance Analysis;

- Ishikawa in Methods of

Evaluation of Process Outcomes; and,

- Taguchi in the Analysis of the Consequences of Quality.

Several myths, particularly in shipbuilding, have been that workers lack commitment and integrity, that it is difficult to install incentives, and that shipbuilding is not suitable for introduction of advanced process and management technology. Furthermore, many have felt that it is a craft type industry in which total quality is difficult to manage because there are so many unknowns.

The fact is that this is precisely why the industry can benefit more than others from effective technology and quality management, as noted from the productivity and quality improvements achieved by high labor cost countries such as Japan and Germany who have introduced thousands of robots and other advanced product design and process technology equipment to achieve major improvements in productivity and total quality.

THE PROCESS OF MANAGING TECHNOLOGICAL CHANGE AND QUALITY

Managing technology and quality requires continuous updating of situation audits in which the existing performance of technology and people (including procedures, etc.) is evaluated in order to determine how well these most important factors perform. Table I is a simple listing of the major steps used in the management of technology and quality. In today's environment, large enterprises and particularly shipyards must update their situation audit at regular intervals by determining their situation audit at regular intervals. A typical outline of a situation audit is shown in Table II. After the condition of the shipyard has been established, its objectives in financial, product, market share, and in other terms must be reviewed.

The performance of the currently used technology and the application of resources in its uses can best be determined by computing both total and partial factor productivities for individual processes, process centers, and the whole shipyard (complemented by computation of the total and partial productivity learning curve to determine the current and expected future role of change of productivity) by tracking productivities from audit to audit. This also provides effective signals of impending changes and projections of possible improvements in performance, if any. This is particularly important in shipbuilding where shipyards seldom

TABLE I - MAJOR STEPS IN THE MANAGEMENT OF TECHNOLOGY AND QUALITY

1. **Technology Situation Audit**
   - Determination of Market Niche
   Performance of Existing Technology
   - Availability and Cost of Factors

2. **Objective Review and Setting**
   - Evaluation of Market (Product) Market Share, Economic and Strategic Objective
   - Setting of non-conflicting multi-objectives

3. **Technology Evaluation & Forecast**
   - Identification of Product and Process Technologies
   - Forecast and Evaluation of Technology Developments

4. **Market Demand**
   - Establishment of Market-Product Demand,
   - Establishment of Market-Quality Demand
   - Establishment of Competitive Market Factors

5. **Setting and Reevaluating Constraints**
   Analysis of Regulatory Constraints
   -Analysis of Financial Constraints
   Analysis of Environmental Constraints
   - Determination of Labor and Resource Availability Constraints

6. **Threat and Opportunity Analysis**
   - Identification and Quantification of Threats and Opportunities

7. **Technology Feasibility**
   Determination of Basic Feasibility
   - Determination of Constraint Feasibility
   - Determination of Competitive Feasibility

8. **Selection of Technology for Change**
   Selection of Decision Requirements
   - Expert Choice Modeling
   Comparative Performance Evaluation

9. **Management of Technological Change**
   - Planning and Management of Technology Transfer
   - Technology Implementation

TABLE II - **SITUATION AUDIT**

1. Current performance of organization, plant, processes, resource use, etc.

2. Position in learning curve of different technologies in use.

3. Availability and cost of factors (labor, capital, subcontractors, services, etc.).

4. Place in market - Product acceptance - Market niche.

5. Organizational condition-Manpower status - Public acceptance.

benefit from long runs of near identical products. It is therefore important to track changes in productivity with changes in product, and use these results as a guide to marketing, to prevent sliding into markets a particular shipyard which may be ill equipped to compete, as shown in Figure 1. The learning curves also help to show the stage of development of the technologies in use and the potential for further improvements.

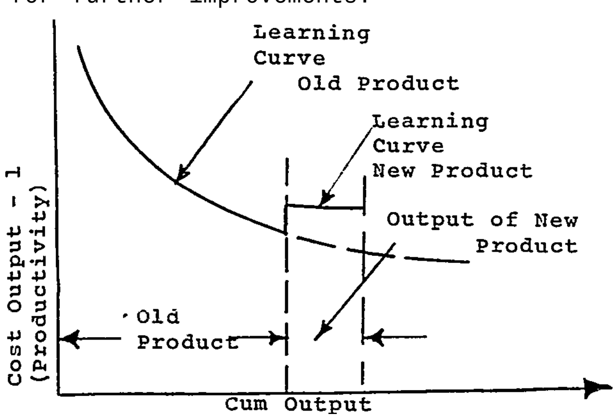

Figure 1 - Change in Learning Curve with Product Change

Although learning curves do not indicate the diffusion or state of innovation of the technology per se, they do indicate if and when technology in use will no longer offer improvements. Similarly learning curves of competing technologies provide an effective means for determining their state and potentials. This is important particularly as we normally know the state of the technologies on the "S", or technology development, curve when first introduced (Figure 2).

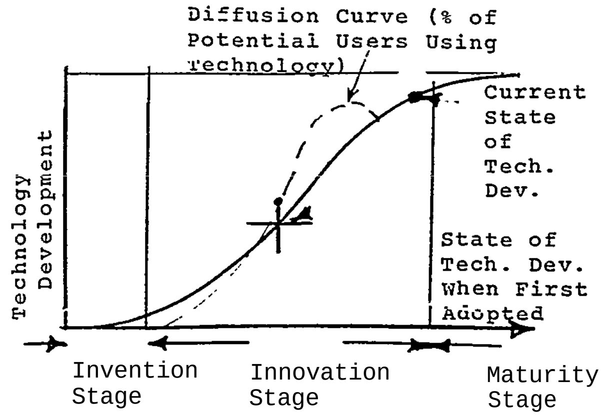

Figure 2 - Technology Development Cycle

This permits an evaluation of our use of the technology. In other words, did we move down the learning curve in line with the technology improvements on the "S" curve achieved during the period since introduction of the technology in our plant?

The availability and cost of factors are determined in both real and current terms and include evaluation of their accessibility. Here one must also determine our factor costs in relation to that of competitors. The place in the market is determined in both absolute and relative terms. Finally, review manpower availability, organizational structure, staff morale, and teamwork is required.

The next issue is the reevaluation of the yards' objective. Traditionally this was simple short term profit maximization, but one increasingly finds that objectives cannot only be financial and should certainly be medium to long term. They should include market penetration and share, product uniqueness, and other strategic goals which advance financial objectives indirectly. The objectives should be clearly stated and have associated metrics in absolute and comparative terms, to permit testing of the impact of changes on the overall multi-objective function.

Technology evaluation should be a continuous activity in which both product and process technologies are tracked in terms of their state of development, performance, and demand. New potentially useful product and process technologies should be identified (often in completely unrelated fields). To forecast technological developments, cross-impact analysis is useful, supplemented by technology development ("S" curve)

analysis, to determine the status and trend of development of a technology on the basis of the factors driving that technology's development. This often includes estimates of the diffusion of the technology both within shipbuilding and the shipbuilding market, as well as in other sectors.

such technology status audits should be performed regularly, and information on technology developments recorded in a standard and usable form. The result of this stage of the management analysis should be sets of "S" or technology development curves with the current state and associated diffusion achieved by the respective technologies, as shown in Figure 2.

Market demand is next determined in terms of product characteristics, quantities, and quality. Price/quality relationships should be established and related -to process technology requirements and costs. Similarly, competitive market factors must be identified in terms of product, quality, quantity, price, and delivery time. These results can then' be used to establish demand curves, which in turn permit computation of demand elasticity with respect to product technology (ship type, etc.) price and quality. Deployment or Quality Function Deployment is a widely used tool to translate "the voice of the customer" into product and process characteristics, and to develop comparative market analyses.

Next, all the constraints in terms of regulations, financing limits, labor and resource availability, work rules, and more must be defined. A typical shipyard situation audit lists the:

1. work in process;

2. material inventory by volume and value;

3. cumulative and marginal cost of work in process and materials inventory;

4. order book (volume and value);

5. current process productivity and status on learning curve;

6. resource (processes, facilities, workforce, etc.) use and percent utilization of capacity;

7. relative process productivity or comparative costs (when compared with major competitors or in case of material or service supplies with costs of alternative suppliers);

8. current constraints such as credit lines, costs of capital, availability of labor, work rules, environmental protection requirements, etc.;

9. market position, market share, etc.;

10. current organization, decision structure, MIS, etc.; and

11. other.

This concludes the situation audit and establishes the existing conditions as well as the trends and opportunities. It also permits identification of potential threats (such as obsolescence of currently used technology or product lines).

The shipyard is therefore now in a position to define near term as well as strategic threats and opportunities and associate these with resulting consequences (given they materialize), assuming the present state, in terms of resource use, market, and operations, is maintained by the shipyard.

At the same time, ranges of possible outcomes, resulting from the implementation of various new strategies, are defined based on actions taken to counter threats or advance benefits offered by opportunities. A formal approach to such a threat/opportunity analysis is given in Reference 1.

The actual management of technological change is now set to be performed. This usually starts with a technology feasibility determination. One attractive approach to determine the feasibility of various technologies within resource constraints is to use a technology performance diagram as shown in Figure 3. Assuming the isoquants of all alternative technologies are known in terms of limited resources, such as capital and labor, it is easy to determine the feasibility of alternative (process) technologies as certain required levels of output (isoquant levels), thereby eliminate those technologies which cannot be feasibly used within these constraints, and which otherwise would result in their operating below their most efficient levels.

Assume for example that semi-automated welding technology B is currently in use with an optimum (least cost) level of operation at the required output q_1 at which the isocost of say C_1 is tangential to the isoquant q_1 and the expenditure for labor is equal to that for capital and both consume $C_1 2$.

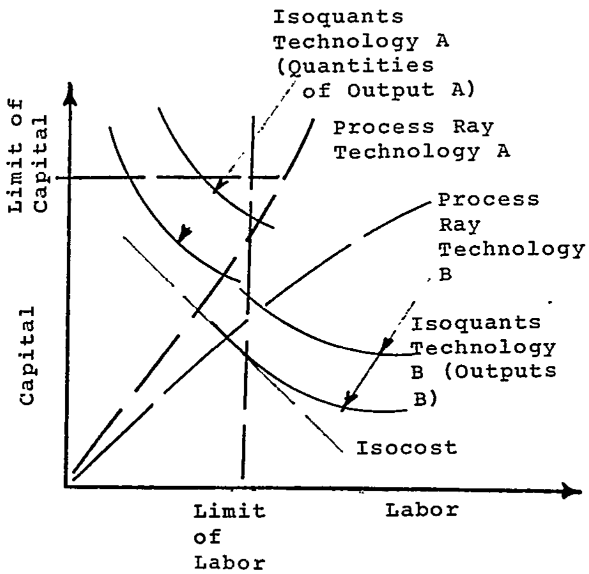

Figure 3 - Technology Performance Diagrams

A new automated welding process, technology A, with a greater learning (productivity improvement) potential now becomes available. For an output of q_1 it also requires a cost of C_1, but capital expenditure at this time is $2C_1/3$. while labor costs are only $C_1/3$. While a switch to the new capital intensive technology A may not provide immediate advantage, improved productivity and potential future increases in labor costs may make a change over to A quite attractive.

In addition to the resource constraint, feasibility, quality, cost (or productivity), and similar constraints must be determined. Then only process technologies which satisfy all these feasibility requirements are maintained among process technology choices. Similarly, potential product technologies must be subjected to-market demand feasibility. price feasibility. and related tests to be maintained in the choice list. Here it is found useful to compute traditional microeconomic demand curves not only in terms of volume of demand as a function of price, but also include demand as a function of performance, quality, etc. and in turn relate price (or cost and profit) to performance and quality and the resulting impact on demand. In most cases such demand feasibility can be determined by use of traditional marketing procedures.

Finally, the stage is reached at which selections can be made from among the process and product technology choices identified, which passed the feasibility test. For this purpose, it is advisable to use an expert choice decision model (described in more detail in another paper by the author).

Such a hierarchical model permits the introduction of all the feasible technological alternatives (for particular problem or market), the various outcomes, the threats and opportunities possibly affected by the choice of technology for that purpose, the various performance measures, and, finally, the outcomes of objectives conditioned by the choice of technology and materialization of a threat or opportunity.

Sometimes there is more than one decision maker involved such as in product technology choice where users, owners, the shipyard, and investors may all place different weights on the various objectives.

Using a method of pairwise comparative weighing, the priority each decision maker places on each technology can be determined in terms of its

a. performance (quality, output, etc.),

b. cost,

c. effectiveness to counter threats or take advantage of opportunities, and

d. importance of objectives to the decision maker.

In this manner, the alternative technologies can be ranked and an effective choice can be made. Now remains only the management of the actual transfer and implementation of the technology.

CONCLUSIONS

The formal approach to the management of technological change decisions in processes and products is particularly important in shipbuilding where process and product changes usually involve large investments and resources and long term commitments. It is therefore important to assure that technological change decisions are made formally, rationally, and based on the best knowledge of one's own condition, technological opportunities, impending opportunities and threats, existing and future constraints in such a way as to most effectively advance the objectives of the shipyard.

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